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ABSTRACT

This paper attempts to examine the research of split-brain, hemispheric specialization, and brain function, as it pertains to handwriting, brain wave patterns, and lateral differences. Studies are reviewed which point to asymmetric differentiated functions and capacities of the two cerebral hemispheres in split-brain patients and in normal persons. The need for integrated hemispheric processing in teaching metaphors, visual imagery, and mind-mapping is discussed. The issue of right- and left-handedness is considered in studies of blood flow, inverted and noninverted writing posture, and familial versus nonfamilial left-handers. Lists of the functions of the two hemispheres of the brain as outlined by various authors are presented in a section on cerebral dominance and hemispheric functions. The final sections of this paper address the implications of the reviewed research for childhood education and the possible identification of children with different cognitive learning styles. Findings are presented which suggest that for optimal cognitive functioning interhemispheric functioning is necessary. The implications of brain research for education in the arts are discussed. In a presentation of mental processes and brain waves, four basic EEG wave pattern categories are described. Two of these, theta and alpha waves, are then used as prototypes to describe variances in children's learning styles. A list of left- and right-minded characteristics that teachers and psychologists can use to look at children's behaviors in a new way is included. A 23-item list of references concludes the document. (NB)

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BRAIN RESEARCH:

Implications for Education

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Brain Lateralization: Historical Background

Over 80 years ago, a doctor, Lotmar, [illegible] reported and discussed research paper at a medical society meeting held in Montpellier, France. The topic of his paper was a summary of his observations concerning his work with patients who suffered from aphasia, the loss of speech following brain damage. Lotmar noticed an association between this loss of speech and the side of the brain where the damage had occurred -- in more than 80 of his patients, with aphasia, the damage was to the left hemisphere; only two had in fact been able to report even the loss of brain damage to the right hemisphere alone. He concluded, therefore, that the hemisphere has specialized functions, and further, that the left hemisphere controls speech.

Unfortunately, his paper was not well received. Dax died the following year and his work was all too soon forgotten; never would he realize the true significance of his own discovery. Instead, it is Paul Broca (1960), who is "properly" credited with being the first to bring to the attention of the medical community, as a whole, the asymmetry of the human brain with regard to speech. In addition, he linked that asymmetry with hand "preference" (Springer & Deutsch, 1981, p.11).

This paper attempts to examine the research on split-brain, hemispheric specialization and brain function, as it pertains to handwriting, brain wave patterns and cultural differences. Another area addressed is the implications of the research for childhood education and possible identification of children with

different cognitive abilities, etc.

Commissurotomy

The brain is divided into two halves, each an approximate mirror-image of the other. This does not imply equivalence; rather, there is an "asymmetry of function" of the two cerebral hemispheres, for each often must perform the same basic processes. As recent research clearly proves, it is now questionable whether researchers should continue using the term "lateralization" to describe brain differences or the two hemispheres in humans. Sperry (1969), for instance, proposed that humans "are possessed not of one, but four brains" (p. 10). He believes that we have a mutual division, cerebrum to cerebrum, and cerebrum to cerebellum vs. digital. As Sperry states:

> In this sense we really have four brains: i.e., multiple possible cerebral organizations, each of which is activated in its own special circumstance, dominant for the moment only to be dominated in turn by other more appropriate to new changed conditions. Has four brains, have we, to four categories of many brains...(p.111).

Recent interest during the past two decades on hemispheric research focused on split-brain patients, so-called because they "have undergone surgery to cut the cortical pathways that normally connect the cerebral hemispheres" (Springer & Deutsch, 1981, p. 4).

Between 1900 and 1950, the corpus callosum was studied to find out what most neurons were its brain structures (Sperry, 1982). In a series of animal experiments conducted during the 1930's, Ronald Myers, more prominent in this research, brought forth scientific evidence dealing with the function of the corpus callosum in the inter-hemispheric transfer of visual

[illegible] learn [illegible] to relate [illegible] function to [illegible] "preventive [illegible] types of learning and memory, [illegible] the [illegible] of the other hemisphere. [illegible] to [illegible] each of the [illegible] hemisphere has a complete [illegible] for the [illegible] of the other..." (Ibid., 1982, p. 87).

Through the use of these special techniques that isolate the contributions of [illegible] hemisphere at a time, the neuropsychologist, along with the scientist, have been able to demonstrate significant differences in the functions and capabilities of the two cerebral hemispheres in these split-brain patients. Springer and Deutsch (1981) report that

> The left hemisphere has been found to be predominantly involved with analytic processes, especially the production and understanding of language, and it appears to process input in a sequential manner. The right hemisphere appears to be responsible for certain spatial skills and musical abilities and to process information simultaneously and holistically (p. 4).

Only in recent years has it proven [illegible] to demonstrate differentiated functions [illegible] in normal persons as well as split-brain patients. An important consequence of these discoveries is the abundance of speculations concerning what [illegible] metrics mean for human behavior. Just a few examples are:

(1) The traditional dualism of intellect vs. intuition, science vs. art, and the logical vs. the mysterious.

(2) The issue of hemispheric [illegible] for differences in intelligence and creativity.

(3) Speculation about the "division of labor" between the two hemispheres related to the diverse problems of learning disabilities, stuttering, and schizophrenia.

Laterality and Cerebral Specialization

Research on split-brain patients helps confirm that speech, in most humans, is under the control of the left hemisphere. But what about other language-related abilities? From the current research (Bogen & Bogen, 1969; Nebes, 1974) there appears to be a genuine difference in the type of written material each hemisphere can understand. The right hemisphere seems to have abilities equal to the left hemisphere's; its limitations appear to be oral or verbal expression. Nebes (1974) proposed the teaching of certain skills requiring integrated hemispheric processing. The metaphor is one example; visual imagery and mind-mapping are two others discussed.

Recent experiments mapping activity in the brain by electrical stimulation has led researchers to believe that mental functions are not as localized as was originally thought. Ojemann and Mateer (1979) reported their research involving probing the brains of neurosurgery patients with electrodes. When these patients were asked to read aloud simple sentences, they were unable to speak specific parts of speech [i.e., the noun or the preposition], depending on the area being stimulated. Ojemann and Mateer further discovered that the same region in control of word-reading also recognized the phonetic sounds that make up words; that stimulation of Broca's area caused deficits in voluntary control of facial movements; and that language deficits varied markedly among their patients.

Another area of research involving blood flow activity is hand preference. A right-handed person has greater blood flow

on the right and left-handers more frequently than right on the left (Bradshaw, 1980). It has not been determined, however, whether this difference is present at birth, as primarily due to genetic influence, or is developmental. One developmental factor is left-handedness is mild brain damage due to birth complications. A higher percentage of left-handers suffer with mental retardation, learning problems, epilepsy, and stuttering. It is also noteworthy that these groups have many left males than females; apparently since males are more vulnerable than females to almost all developmental difficulties, both biological and psychological, perhaps then, the increased left-handedness is more a result of such vulnerability rather than a source (Bradshaw, 1980, p. 140).

Levy and Reid (1978) tie not only handedness but also writing posture (inverted vs. noninverted) to brain organization for language. Levy and Reid claim that, regardless of hand preference,

> the noninverted position indicates the same hemisphere for speech dominance and hand preference and inverted position indicates opposite hemispheres. Thus, right-handed inverters would have language in the right hemisphere, and left inverters in the left hemisphere...[However,] the number of left-inverters is not sufficient to account for the 70 percent of left-handers who are left dominant for language (1980, pp. 145, 140).

Another important distinction to consider is familial vs. nonfamilial left-handers. It is important because

> neuropsychological tests have shown that the cerebral organization of nonfamilial left-handers is lateralized in a way identical to that of right-handed people, whereas familial left-handers have more bilaterally represented verbal and non-verbal functions...Thus, it can be concluded that familial left-handers have less cerebral asymmetry than

Psychometrics (Holt-Rinehart, 1966, pp. 79-93). Over further research findings see: Robert Ornstein, Editor, 1971, 19-44.)

Those familiar left-hemisphere, when, how concentrate more symmetrical brains and bilateral speech, pose a considerable problem for theorists until they can demonstrate a particular disadvantage in left-hemisphere having symmetrical brains, i.e., what would be the reason for specializing motor functions in only one hemisphere?

Left vs. Right Brain Characteristics

From the onset of the first split-brain operations, a number of labels have been used to describe left brain - right brain processes. However, those labels most widely cited can be separated into five main sequential groups. Each group generally includes and extends beyond those characteristics directly above it.

Left Hemisphere:	Right Hemisphere:
Verbal	Non-Verbal, Visuo-Spatial
Sequential, Temporal, Digital	Simultaneous, Spatial, Analogic
Logical, Analytic	Gestalt, Synergic
Rational	Intuitive
Western Thought	Eastern Thought

The functions of the two hemispheres were also outlined by Paul Bakan (1969) concerning differential hemispheric functions. He offered the following classifications:

Left Hemisphere	Right Hemisphere
Verbal	Pre-Verbal
Analytic	Synthetic
Abstract	Concrete
Rational	Emotional
Temporal	Spatial
Digital	Analogic
Objective	Subjective
Active	Passive
Tense	Relaxed
Empiric	Depressed
Sympathetic	Parasympathetic
Propositional	Appositional

(Tansey & Hoser, 1975, p. 12)

A more physiologically based brain model is offered by Nagelski (1976) who worked on a joint project of the U.S. Office of Education and the John F. Kennedy Center for the Performing Arts, with the Music Educators National Conference. In his book entitled, Arts, Education and Brain Research, Nagelski (1976) explains some of the reasons why the right hemisphere of the brain has come to be "neglected" "The left hemisphere is seen to be intellectual while the right hemisphere, in comparison, is considered intuitive or introspective. From this arises the prejudice of regarding the left hemisphere as major and the right hemisphere as minor" (p. 7). Nagelski not only describes the functions of the left and right hemispheres but also offers an interesting diagram of the brain, indicating locations of the various functions of the hemispheres.

Figure 1

Relative Degree of Activity for the Contrasting Modes of Mental Functioning*

Left	Right
a linear	a circular
b sequential	b simultaneous
c logical	c alogical; paradoxical
d analytical	d synergic; synthesizing
e verbal	e nondiscursive; preverbal
f fragmenting	f combinative
g differentiating	g holistic
h convergence: seeks closure	h divergence: content with open-endedness
i denotation	i connotation
j commonplace signs	j expressive gestures
k conventional symbol	k art symbols; metaphor
l facts: objective impersonal, confirmable	l feelings: subjective, personal, judgemental
m precision, clarity	m diffuse, vague
n explicit	n tacit; implicit
o sympathy	o empathy
p Scientific Empiricism/Logical Positivism/Certitude/Surety	p Immanence/Introspectionism/ Intuitionism/ Intuitive Cognition /Insight /Intuition

* Placement of numbers in hemispheric locations reflects the relative degree of functional activity or responsibility of the hemisphere (and its special modes or activity), and NOT the actual physical or anatomical location of the activity or quality in question.

(Kaplan, 1970, pp. 20-21

of the Hemispheres and Education

The primary role of the left hemisphere is well documented in regards to the "basic skills." Language and reading skills are principally left hemisphere functions. Mathematical, calculations and algebra are considered left hemisphere functions as well, while writing skills tend to require both hemispheres (Rubenzer, 1978). However, evidence is mounting that illustrates right hemisphere functions pertaining to educational settings. For example, analyzation of voice intonation is a right hemisphere function and is also an integral factor in language. The ability to recognize a face and to interpret and remember complex visual patterns are also right hemisphere functions, as well as iconic memory (Rubenzer, 1978). The ability to interpret and remember complex nonverbal auditory patterns (ie., music, morse code) occurs in the right hemisphere (Kimura, 1967 & Rubenzer, 1978). Proprioception and haptic or tactile perception are also considered to be right hemisphere functions (Kimura, 1973 & Brandwein & Ornstein, 1977). Corresponding academic subjects are: language arts and art; algebra and geometry; music and band; and physical education, respectively.

Recent findings indicate that for optimal cognitive functioning interhemispheric functioning is necessary. Jonas Salk (1973) stated the significant application, in scientific discoveries, of the synthesis of both left and right hemisphere processing modes. Sperry (1968, 1973) also reported the integration of both hemispheres is achieved when one is functioning in the "synergetic" or creative/inventive mode. It is therefore purported that a balanced symbiotic approach to brain functioning in learning and education be

implemented, the earlier in one's life the better (Hegeleki, 1976; Kusemer, 1976; & Pacely & Hosler, 1979).

Brain Research and Education in the Arts

It is now believed that the right hemisphere controls the essentials of aesthetic functioning, which has holistic ability to integrate, and is considered to be intuitive and introspective; the left hemisphere is seen as intellectual, abstract, and analytical (Hegeleki, 1976).

Many researchers and educators claim that American educators educate only half the child, in teaching those aspects that are primarily left-brain functions. Hegeleki, (1976) along with Pacely and Hosler (1979) and Fincher (1976) call for the synthesis of left and right hemispheres to unite into "the synergic mind" (Hegeleki, 1976, p. 8). This may be the primary function of the corpus callosum: Ultimately what is at stake in the proposal to more equally educate both hemispheres is the question of human freedom. A balance is needed in order to allow the individual the freedom to choose which mode of consciousness to apply...It is important for art educators that their students have this freedom to choose aesthetic pursuits and that this freedom is not lost (Hegeleki, 1976, pp. 25). This would demand a new understanding by all educators, and in particular, art educators: that there are differences between left and right hemisphere functions, and further, that these differences are reflected in their students, according to their dominant hemisphere. In fact, Soares & Soares (1984) report estimates that the national prevalence of right-brain dominant children, grades K-12 for 1980-81, was approximately 41,000,000, with at least 10 percent of them being

left-handed.

Mental Processes and Brain Waves

The study of EEG patterns has become "the most accurate measure of the neurological concomitants of mental activity [because] EEG pattern analyses are more direct and reliable measures of determining neurological processes of the brain" (Rubenzer, 1978, pp. 30-31). There are four basic EEG wave pattern categories -- delta, theta, alpha and beta. Two of these, theta and alpha, are later used as prototypes to describe variances in children's learning styles.

(1) Delta - The delta wave is a slow frequency wave ranging from .5 to 3.0 Hz (cycles per second) and is recorded mostly during deep sleep and the dream state (Brown, 1977).

(2) Theta - The theta wave occurs within the 3.5 to 7.5 Hz. frequency range and is usually recorded in the preconscious state, ie., between dreaming and waking. It is in this state "that insights or shifts in perspective and states of reverie occur" (Rubenzer, 1978, p. 37), and are thought to be the sources of creativity and ingenuity. The average individual experiences this state only five percent of the time; however, truly creative persons are thought to be able to consciously evoke this state.

(3) Alpha - The alpha wave state occurs between 8 to 13 Hz. and is associated with problem-finding, internal focus of attention, and limiting of the perceptual field. Creative and reverie states are also noted during alpha wave patterns (Green, et al., 1970).

(4) Beta - The beta wave ranges from a frequency of 13.5 to 40 Hz. and is manifested by external focus of attention, increased problem-solving ability, and quicker reaction time, described by Deikman (1971) as the "action mode". Research is now being directed toward conscious elicitation of alpha and theta waves "for the explicit purpose of facilitating the cognitive and affective states most often associated with creativity" (Rubenzer, 1978, p. 45).

The major implication for education is that with more accurate assessment of a student's physiological and hemispheric functioning and learning strengths, a closer match could be derived between his or her learning styles and the appropriate methods of instruction to enhance and improve learning potential. Not only could it be

determined which hemisphere is dominant, but also which modes of thought, via EEG patterns, might be elicited to enhance the learning or mastery of the task at hand. Of course, the important goal is to incorporate and synthesize these forms of thought in order for the child to attain a higher level of personality, awareness and achievement than can be attained by just one thought process alone.

Cognitive synthesis should be the true goal of learning. It is one thing for educators to provide children the guidance to learn the tools of culture: language and values; it is another more difficult thing to provide the proper environment that facilitates their ability to utilize those tools in discovering meaning in their lives and reason for their behavior.

The mental processes involved in naturalized thought (right hemisphere) involve the child's ability to "understand his sensory world, to organize and understand spatial information, and to develop intuition and insight through a 'gestalt' of nonverbal information (Fadely & Hosler, 1978, p. 100). The mental processes of socialized thought (left hemisphere) involves the child's ability to "order, to symbolize, to organize, and to evaluate information" (p. 100).

Characteristics of the Theta vs. Alpha Child

The concept of the Alpha Child has important ramifications for education and the curriculum which stresses mostly socialized and left-minded learning but which also involves naturalized right-minded learning. An equal emphasis must be attempted, "if we are to help those children with differences, as well as to

provide for all children a program that will develop their full natural and social personalities" (Fadely & Hosler, 1978, p. 69).

The Alpha Child is the "soul" of our culture; the Theta Child is its technology. These two types of children represent the two polarities of man: socialized and technological vs. naturalized and intuitive. The Theta Child is socially and verbally active, overly concerned with time and possesses the ability to name everything, but finds it makes little "sense" to him. The impact of these differences are of paramount importance within the school setting.

> The Theta child has basic personality imperatives to become highly socialized and achievement oriented in school. Competition, nearly unknown to the Alpha child, becomes a frantic fixation...The Theta child feels lost without definite guidelines and rules. It is the Theta child who gives so much pleasure to the parent and teacher (Fadely & Hosler, 1979, p. 125).

Understanding the Alpha Child is another matter. These children display much higher cognitive functioning in nonverbal or naturalistic thought, who appear to have the right hemisphere as their dominant mode. Such a child would display deviant learning characteristics and personality traits. There is a general tendency toward <u>consonant</u> hemispheric dominance and motor dominance (handedness)in most children. However,

> It may well be that many children who are seen as learning disabled, hyperactive, or distractible are children who may have <u>dissonance</u> between motoric and cerebral dominance. It is suggested that many such children are in fact special sorts of children, the Alpha children...
>
> These children may be right- or left-handed, though they are in most cases <u>right-handed</u>, and are <u>right-minded</u> individuals who appear to view their world in a characteristically right-minded way, even while they are able to function in the usual fashion of the left hemisphere activity. The individual child has no pathological abnormalities and no

distinct learning disabilities; he is merely organized neurologically in a different manner. We call him an Alpha child (Fadely & Hosler, 1979, p. 60, 68).

These authors developed a list for the classroom teacher to provide "a general orientation for observation and discussion by the teacher, psychologist, and parents" (p. 151). When correctly used by the teacher and psychologist, it will enable educators to look at children's behaviors in a new way. In an "average" child a correlation between the two modes of naturalistic and socialized modes of thought is attained. The children with whom educators must be concerned are those who score higher in either mode. Below is the list that they developed.

Left-Linked Characteristics	Right-Linked Characteristics
A1 VE Verbally Expressive	A2 ME Motorically Expressive
B1 L Logical	B2 I Intuitive
C1 OS Orderly and Sequential	C2 HG Holistic and Gestalt
D1 T Time Orientation	D2 S Spatial Orientation
E1 SV Socialized Values	E2 NV Naturalistic Values
F1 AA Aggressive Assertive	F2 SA Submissive Accepting
G1 AT Abstract Thought	G2 CT Concrete Thought
H1 VT Vertical Thought-Structured	H2 LT Lateral Thought-Creative
I1 O Objective	I2 S Subjective
J1 CM Conventional Motor Organization	J2 MU Mixed/ Unconventional

(Fadely & Hosler, 1979, p. 151).

Fadely and Hosler (1979) also developed a detailed checklist of specific behaviors incorporating the previously mentioned 10 characteristics of socialized and naturalized behavioral, cognitive, affective, and personality factors. Five levels of scoring are used in the checklist, ranging from 0 for inadequate to 4 for superior ability. The class as a whole is used as the norm reference group, and each child is subsequently compared to the class to determine the score. They state the "average" child should score an approximate total of 200 points while the Socialized vs. Naturalized modes used by a child would be approximately 100 points.

Once these children have been identified, then the teacher (with the help of a trained psychologist, or diagnostician) can deal with them through educational techniques. Moreover, not just with those children needing clinical or remedial therapy but also with those who are not pathological, but rather different in developmental and neurological organization.

> The real problem is that the <u>basic thinking</u> of the entire educational establishment must be changed before real results can be obtained. The real changes are only going to come slowly, as the teachers themselves change.
>
> A real reform of the education system will not occur until <u>the individual teachers learn to understand the duality of their students' minds</u> (Blakeslee, 1980, pp. 56-59).

In order to reverse this process of educating only half of the brain "Teachers must learn to <u>feel</u> their nonverbal consciousness and to respect intuition and nonverbal thinking" (p. 60).

A Final Word

If the above mentioned types of learning differences can be understood as a uniqueness in a child's nature, and consequently viewed within the range of "normal behavioral possibilities," then mislabeling children as learning disabled, behaviorally disturbed, or socially deviant will have been circumvented and they will be given the opportunity to learn at an optimal level and become more fully appreciated, an opportunity which is most rightfully theirs.

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